VOL. IV, No. 1
SPRING, 1956

PUBLISHED
QUARTERLY

RESEARCH TRENDS

CORNELL AERONAUTICAL LABORATORY, INC.
4455 GENESEE ST. BUFFALO 21, N. Y.

COMPUTERS — Drafted for MILITARY SERVICE

by WILLIAM S. HOLMES

DEVELOPMENT OF MILITARY COMPUTERS REQUIRES MANY DIVERSE SKILLS

Military computers reflect the increasing role which scientific know-how plays in military success. The World War II Norden sight, famed aircraft bombing sight, is a good example of the opto-mechanical computer. As radar was refined and electronics began to be a major factor in warfare, many new military techniques were conceived. Radar, the new way of "seeing things," penetrated the veil of weather, darkness, and distance to reveal invaluable military information. This information can be used by defense forces to direct anti-aircraft fire accurately against invisible bombers, or to guide fighter aircraft onto the tail of enemy bombers. For attacking forces, radar information can be used to bomb accurately through cloud cover at night, or to shoot down an invisible fighter on the bomber's tail.

But even with accurate radar data, one does not aim an anti-aircraft gun directly at a bomber 15,000 feet up; the shell follows a curved path and takes several seconds to reach 15,000 feet. Ignored, these factors would be sure to guarantee failure. Of course, gun-laying computers to compensate for the curve and time lag existed before radar, but radar, the new precise source of electrical data, stimulated development of the electro-mechanical analog computer, such as one developed by C.A.L. (Figure 1).

COMPUTERS AND MATHEMATICS

Analog computers are instruments in which physical quantities are represented by electrical voltages or by mechanical positions. The voltages may be ac or dc. The positions are usually rotational as in a resolver or potentiometer but may be translational.

In 1948 C.A.L. built its first equipment for controlling aircraft fighters to successful interception of attacking bombers. Computers and display equipment were set up in a related effort to help tactical officers of a Navy task force in evaluating an enemy threat and deploying defending aircraft. Air defense exercises were simulated on the equipment, which resembled the nerve center of a modern naval task force.

Computers, the real but "unthinking" children of mathematics, solve mathematical relations using specific

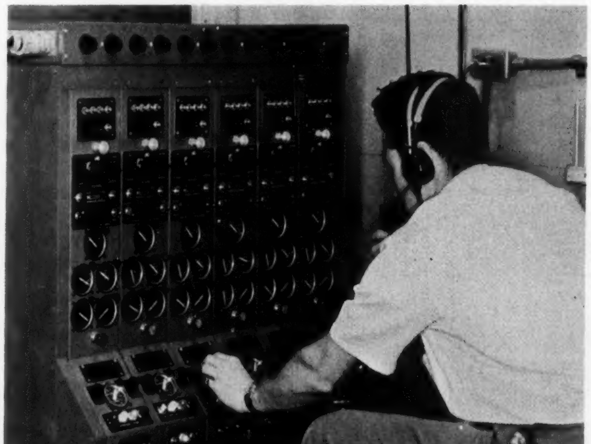


FIGURE 1 — Electro-mechanical analog computer developed by C.A.L. Circuit details, environmental specifications and form factors are united in the final military computer.

quantitative inputs. Some computers, such as gun-laying and bomb-sight instruments, are function generators. They add, subtract, multiply, divide, and produce functions of parameters. Others, such as auto-pilots, tracking systems, and inertial guidance devices, embody integration and differentiation as well as the simpler arithmetic operations.

The entire process of computer design is a closely linked chain. Computers are designed mathematically before they are designed as hardware. The mathematical design states precisely each operation the computer will perform and should not be confused with mathematical analyses which help one to understand the basic problem.

Just as the mathematical design precedes the hardware stage, analysis of the basic military and technical problems must precede the mathematical design. Understanding the real military problem is usually most difficult since many interrelated and sometimes apparently contradictory factors are involved. The trend of development of associated military equipment, knowledge of enemy weapons, and plans, both tactical and strategic, all help determine the boundaries within which a computing system will be confined. The recent comment of a jovial engineer: "It must have zero weight, occupy no space, require no maintenance and out-perform its predecessor" suggests the predicament of the military computer designer. Actually, allowable size and weight, required maintenance and reliability, operator fatigue problems and lack of training together with poor environmental conditions are important considerations in the design of the entire computer system.

In some cases, understanding the military problem may seem unnecessary. For example, the computer engineer need understand few military "facts of life" to design an aircraft Mach meter. Of course, he is conscious of the importance of space and weight as they affect the military efficiency of the aircraft. On the other hand, he is little concerned with tactical considerations, such as optimum flight paths for launching a weapon, even though they might be reflected in the required precision of the instrument.

In other cases, however, understanding the military problem is as important as understanding the engineering problem of designing the computer. For example, computers designed by C.A.L. for use in air defense systems have involved the entire gamut of military technology. Computers for aircraft control, for the extraction of data from search radar and for tactical control of weapons have been studied, designed, developed, and tested for the Armed Forces since 1947. C.A.L. is now engaged in several computer programs tying together radars, communications and aircraft or missiles to make effective weapons for the defense of the nation.

SPECIFICATIONS—COMPUTER CHROMOSOMES

The "chromosomes" of computers are research and development specifications, a type different from that used to control production of computers. The main purpose of the R&D specification is to establish the military intent of the procuring agency, not to control the way the computer will be built.

For example, let us set up a hypothetical specification for a tactical air bombing computer and follow the thoughts of the computer engineer as he ponders the implications.

A ground-based computer system is required to control tactical bombing missions within an area 200 miles square. **"Sounds reasonable. Probably means search radar, or triple station ranging."**

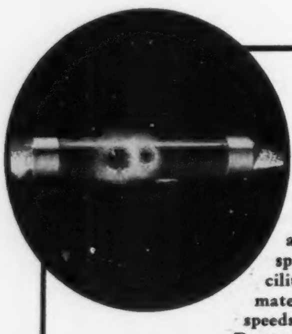
Control should be possible from just after take-off to pre-landing. Capacity should be furnished for 50 sorties per hour and 5 sorties simultaneously in the final bombing run. **"This suggests two modes of control, approach and final bombing. Wonder what peak capacity 50 sorties per hour will force on us? Better get advice from the field on this."**

Missions will be assigned in geographic coordinates by ground liaison observers stationed with advancing troops. **"Those ground observers will help. Maybe I can put a light weight radar control set in their hands."**

Reasonable protection from mid-air collision should be provided. Tactical bombers should not be allowed to enter these areas. **"We'd have wanted to include these capabilities anyway. I can see it will be a fully monitored computer system."** Adjustable approach lanes to targets should provide for automatic evasive maneuvers. **"The moon they want! This one will take some study."**

The fictitious B-99 fighter-bomber will be the weapon-carrying vehicle. Attacks should be possible from all altitudes from 200 to 500 feet above the terrain. Targets will be fortifications, bridges, dams, troop concentrations and unfortified structures. Conventional high explosive and napalm bombs are to be delivered. **"Better get some opinions from the weapons boys on this part."**

Standard deviation of impact should be 5% of the altitude of delivery. **"Sounds like a stretch, but we've stretched before."** Computer and associated system should be so designed that there will be no hazard to



THE COVER

The photo insert at left, also reproduced on the cover page, shows the impact of raindrops on a plastic specimen whirling at high speed. C.A.L.'s "whirling arm" facility for testing the behavior of materials subjected to rainfall at high speeds was developed by the Materials Department under Air Force sponsorship. It simulates up to one-inch per hour of rainfall at 500 mph. Since the program was initiated ten years ago, the durability of plastics and related materials has been increased from a few seconds or minutes to a few hours by the use of air-drying elastomeric coatings. C.A.L.'s research continues today for a better understanding of the mechanism of erosion. Development of new testing equipment for speeds up to 2500 mph is now underway.

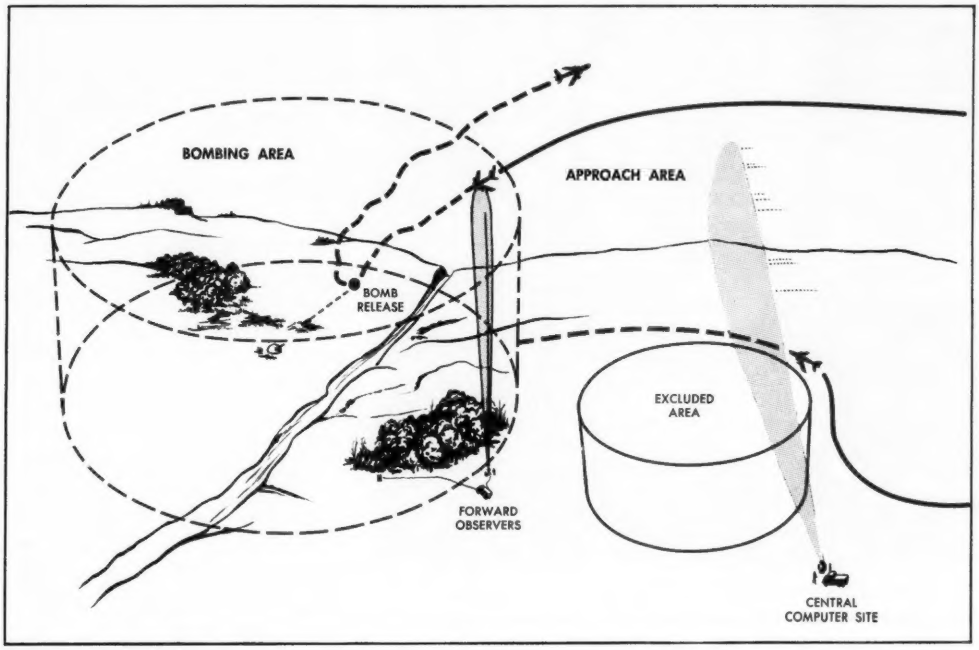


FIGURE 2 — Tactical bombing — a hypothetical system illustrating the application of computers to military situations.

the delivery aircraft or troops being supported. "Uh-huh. **Plus 5%, minus none!**" our engineer concludes.

THE PROPER ENVIRONMENT

This proposed computer system is deeply involved with military reality. Reflecting on the precision demanded, the designer might hope to use a central computer for controlling the entry to the bombing area, with decentralized bombing-run control from a short-range light radar in the hands of the ground liaison observers (Figure 2). The bombing run, however, involves the most sophisticated computations. Consider the requirement for programmed evasive maneuvers while on a bombing run. The computer is likely to be too heavy and bulky for forward observers, and therefore the problem of mobility in combat areas would force the designer to rely on miniaturized computers or to locate the bombing-run computer elsewhere. Perhaps he would still be able to use forward observer data as inputs to a remote computer. If so, he would become more heavily involved in communications problems, with accompanying vulnerability to enemy or natural jamming.

HUMAN ENGINEERING

Computers, in one sense, are "junior mathematicians," and they can use a few social graces. Some computers are completely automatic, but most of them are manually operated. Many display their results to an operator who carries out necessary actions based on the information. For instance, the computer controlling our fictitious B-99 in the approach area might work from search radar information. If so, the aircraft would probably be tracked by men observing plan-position-indicators (PPI's). The computer under these circumstances might tell the operator what to do, or it mght predict the results of what the operator is doing. The first scheme makes a clerk of the operator. The second leaves him in full control of the situation.

Making the computer work with people and determining its final form are jobs for human engineering. Sometimes the form of the computer depends more upon the physical positions operators must assume to operate it efficiently than it does upon space and weight. An airborne computer has to be tucked into the available crannies of the plane. Displays must be visible to the pilot, controls must be accessible, and yet the computer display-controls must not interfere with the other operations of the pilot. Figure 3 shows a wood and cardboard mock-up built to study the problems of form for a surface based computer.

FIGURE 3 — Wood and cardboard mock-up to study the form of the computer.

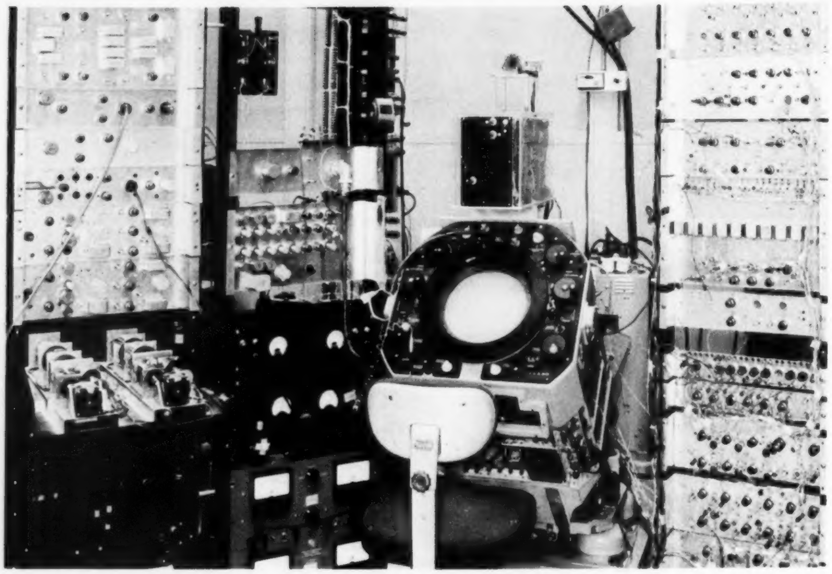


FIGURE 4 — Working breadboard computer used for preliminary studies. It is spread over 3 relay racks to facilitate changes in circuitry.

DESIGN AND BREADBOARD

Design of the computer based on a mathematical description is an engineering problem. The information carrier must be chosen. Shall it be dc, 60 cycles, 400 cycles, or some other frequency? Perhaps dc carrier will be preferable in some sections of the computer while 400 cycles will be best in others. Of course, the correct use of mechanical computation will be an issue. These and other basic engineering considerations are resolved by the computer-design group.

Throughout, as the design progresses, considerations of accuracy, scale factors, and full scale values are important. But since the design activities are directed toward construction of a breadboard computer, the adolescent stage of a fully developed computer, such factors as module construction, cooling, and ultimate form, are given only passing consideration. At this time circuits are changing — sometimes daily. A string of three tubes may be eliminated in favor of a magnetic amplifier. So the computer is built to facilitate change rather than satisfy service or esthetic requirements. Every circuit or mechanism is subjected to extensive functional tests. Finally a working breadboard computer (Figure 4) is operating in the laboratory and ready for tests.

Tests to measure a computer's efficiency in military tasks almost inevitably involve a certain amount of simulation. Such tests are most valuable when as much "real life" as possible is injected, but economy often forces the tests to "pretend" to a certain extent. C.A.L.'s extensive air defense simulation exercises, mentioned earlier, are just such an instance of preconceived, purposeful "let's pretend."

Once past the breadboard hurdle, a computer begins to take different form. Estimates of the space the equipment will occupy lead to wood and cardboard mock-ups. Mock-ups help in the design of packing of components to satisfy juxtaposition, cabling, and cooling requirements. They assist the designer to visualize the maintenance problems of a proposed design, to determine how the design fits the space it must occupy — a consideration particularly mportant for aircraft installation — and they help one to visualize the problems of operating semi-automatic computers.

Temperature rise, vibration and shock, humidity, and many other specification requirements now become important. Operational tests of the final computer are now planned or at least considered.

THE DELIVERED COMPUTER

Gradually the final computer itself takes shape. Wherever possible, it is designed to have identical plug-in amplifiers and major sub-assemblies. These factors make maintenance easier. Both sealed and plug-in relays will be used. Mechanical assemblies are designed for ease of resolver and potentiometer alignment, for ready access in maintenance as well as for resistance to shock and vibration.

One day the computer, thoroughly tested in the laboratory, is ready for delivery, even though the computer project engineer is probably dissatisfied with several minor aspects of its performance. A critical stage in the life of any computer has now been reached. Well conducted operational tests will reveal its deficiencies and indicate how it should be modified for manufacture. It is hoped that such tests will also show up the strengths of the computer and indicate marked improvement in performance of the military task which needs to be done.

Looking back over our process, we find that the engineer needs diverse technical skills to develop a military computer. He must have a knowledge of radar and computer electronics; of practical psychology and mathematics; of communications and mechanics. A special type of engineer is needed — one with a broad technical foundation, a vivid imagination, and an intense devotion to his profession. Most computer problems present a challenge, and good computer engineers revel in meeting challenges.

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"Final Development Report for the Intercept Computer," McDonough, Sidney L., C.A.L. Report No. UA-571-P-31; May, 1955; 172 pages.

"Intercept Evaluator Group AN/SPA-( ) (XN-1), Final Report," Giori, Francis A., C.A.L. Report No. UB-739-P-19; May, 1955; 28 pages.

"MNEMONIC MORONS"

THE AUTOMATIC DIGITAL COMPUTER AS A RESEARCH TOOL

by DAVID FEIGN

In the past decade, modern technology has made available a new tool which promises to revolutionize our way of life: the automatic digital computer. This mnemonic device eliminates mental drudgery from research and development. It was originally developed to aid in the solution of certain scientific problems, but it turned out to be so generally useful that it is being applied to many different fields.

The aeronautical industry gave the greatest initial impetus to its development. In the period immediately following World War II this industry had on order, or in use, over 50% of the computing equipment in production at that time. Some of this equipment was developed specifically for such aeronautical research applications as trajectory and stability calculations and wind tunnel data reduction.

The basic idea of the automatic digital computer is not new. More than a century ago, Charles Babbage, an English mathematician, conceived an "Analytical Engine" which was an automatic computing machine as we use the term today. His idea was not completely fulfilled because no one could make the required mechanical parts with sufficient accuracy. Development of modern technological devices, however, with electricity and electronics replacing mechanical linkages, led to the Mark I Automatic Sequence Controlled Calculator, installed in 1944 by IBM at Harvard University. World War II gave impetus to the rapid development of many other computers. The next decade saw a tremendous epidemic of "acs," starting with the ENIAC and going through the EDVAC, JOHNIAC, MINIAC, BINAC, ILIAC, and even the MANIAC, finally ending with a large scale high speed automatic digital computer, the well known UNIVAC. (Recently the "acs" have disappeared and the machines now have more reasonable names like Datatron, File Computer and Monrobot).

ADVANTAGES OF COMPUTERS

What advantages have these machines over the primitive calculators? The functional block diagram (Figure 1) indicates the basic units out of which automatic computers are constructed. These units may be compared with a more familiar setup: The arithmetic unit of the computer corresponds to a desk calculator, the control unit to a human operator, the input unit to the instructions and data handed to the operator, the output to the results returned by the operator, the storage unit to the sheets on which intermediate results are written, and the tables of functions to the mathematical reference books used by the operator.

High speed is a distinguishing factor of computers. Automatic machines now operate from 25 to 1000 times faster than the desk calculator and the end of the speed race is still not in sight.

The dependability of these machines is even more advantageous than their speed. Computers can operate unattended for long periods of time and perform millions of calculations without an error. A human being with a desk calculator is considered an expert if he can do as many as a hundred calculations correctly. If a problem involves a thousand calculations, a human computer does well to complete them correctly on the third try. This inclination towards error is what makes long complicated problems so difficult for humans to solve. The automatic computer, however, rarely makes mistakes and never becomes ill or bored.

The interpreting and logical functions of this wonder tool led to much excited debate some years ago: is it capable of thought in some sense? These discussions led to a deeper study of what was involved in thinking and imagination. It was soon agreed that comparing this machine with an animate brain was fruitless. It is, actually, a "mnemonic moron," and not a "thinking machine" or "electronic brain," as it is sometimes called in the popular press. It cannot think, but, because of its dependable storage, it can "remember" and follow the detailed instructions carefully prepared by mathematicians.

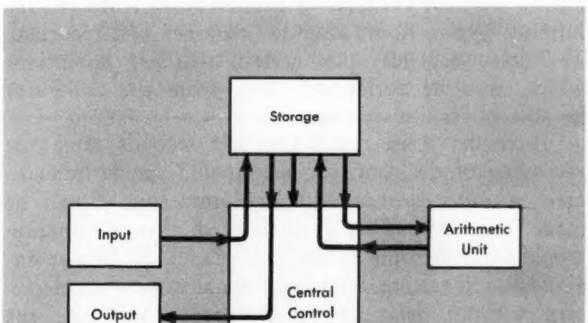

FIGURE 1 — Functional block diagram of an automatic digital computer.

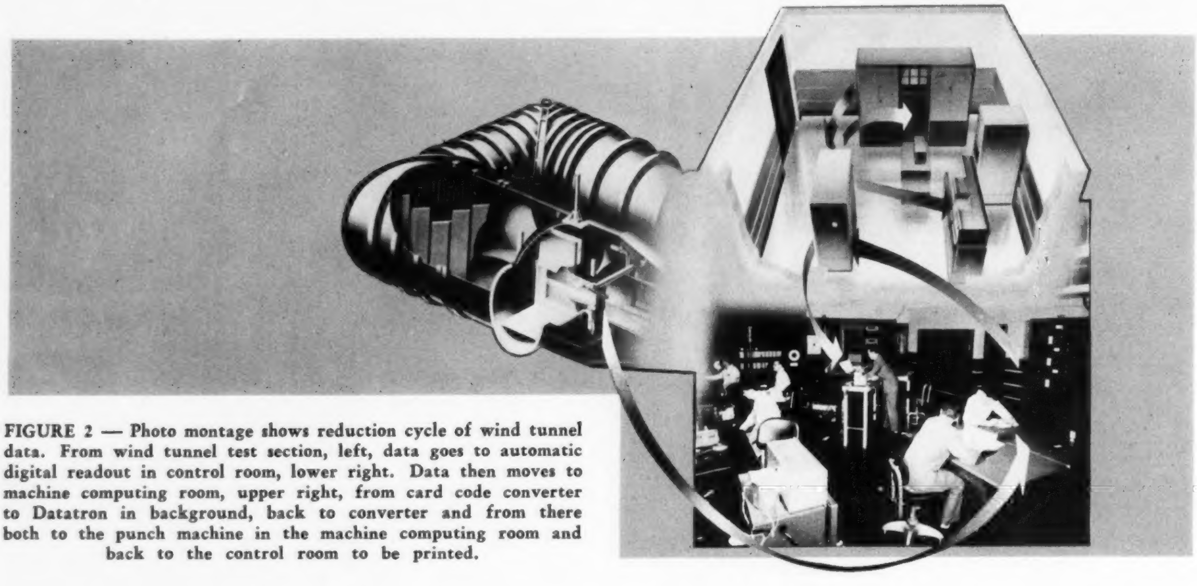

FIGURE 2 — Photo montage shows reduction cycle of wind tunnel data. From wind tunnel test section, left, data goes to automatic digital readout in control room, lower right. Data then moves to machine computing room, upper right, from card code converter to Datatron in background, back to converter and from there both to the punch machine in the machine computing room and back to the control room to be printed.

REDUCTION OF WIND TUNNEL DATA

In the summer of 1950, Cornell Aeronautical Laboratory, Inc. acquired its first automatic digital computer, a Card Programmed Calculator, to facilitate the reduction of wind tunnel data. Later, two more advanced models of the same type were added. Last year, the Machine Computing Section acquired a Datatron computer with a much greater storage capacity and higher speed than the other machines.

The application of automatic digital computers to data reduction is a natural one. The calculations involved are relatively simple but frequently repeated. Once a general setup has been made, the change from one test to another is a simple task. Nearly 200,000 pieces of data from C.A.L.'s 8½ x 12-foot variable density wind tunnel (Figure 2) are recorded in an average week's operation. They could not be handled adequately today without automatic computing equipment. Wind tunnel data are furnished on punched IBM cards, which facilitate feeding them to the digital computer. At present the cards are sorted, automatically merged with a deck of cards containing instructions, and fed into the input of the computer. The results are then available in printed form from twenty minutes to two hours after the data are first recorded. The delay depends upon certain auxiliary operations which must be performed away from the computer because of its limited capacity.

If results were made available seconds after the recording of the data, engineers could decide immediately whether or not additional test runs should be made. The immediate availability of this information would prevent some of the redundancy at present unavoidable in testing, allow additional tests when necessary without delay or extra expense, and ease the crowded wind tunnel schedule. Another Datatron computer is therefore being installed this year exclusively for wind tunnel data reduction. It will be a part of the tunnel's instrumentation, taking its input directly from the pulses which also punch the data card. Five to fifteen seconds later (depending on the amount of data recorded for each point and the complexity of the required calculations) it will print all the final coefficients and also activate a battery of automatic plotters to graph these results. It will also perform additional computations during model configuration changes. For example, while one test is going on, the instrumentation for the next test will be calibrated. This calibration data may be fed into the computer during slack periods so that the calibration coefficients for the instruments will be determined and checked before the next setup is even in the wind tunnel.

COMPUTERS AND FLIGHT RESEARCH

Other forms of data reduction are also being handled by C.A.L.'s Machine Computing Section. The most prolific source of data, after the wind tunnel, is flight tests during which airplanes or missiles are tracked by radar and/or phototheodolites (instruments which give the relative bearing of the object being tracked). In testing a guided missile system, we must determine the flight path of the missile and velocities along this path in order to check the performance both of the missile and its guidance system.

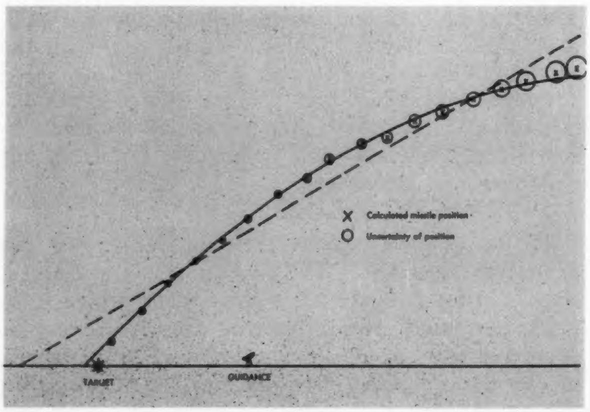

FIGURE 3 — Illustration of trajectory of guided missile. Points represent the measured trajectory. The straight broken line is a poor approximation to the missile trajectory. The solid line parabola fits within the uncertainty of the data.

Data recorded during these flight tests must be reduced to some usable form. Readings from two or more theodolites must be synchronized and combined with the known locations of these theodolites to locate the object in space. The bearing vectors from the different theodolites do not usually intersect exactly at a point, so we must compute both the most probable location and the uncertainty of this location (Figure 3).

Analysis of flight tests may involve the elimination of experimental error by smoothing the data, that is, fitting curves to the data. The uncertainty of the position, which we have calculated as part of the data reduction, now becomes useful by showing how well this smoothing curve fits. For data which may be fitted by a straight line the problem is rather simple but, for fitting more complicated curves, systems of simultaneous equations have to be solved. Figure 3 shows position data on a missile being guided to its target. The data can be satisfactorily approximated by a parabola but not by a straight line.

Determining the velocity of the missile along its flight path may be done by taking the distance between successive positions and dividing by the time interval between these positions (a rather crude but rapid method) or by mathematically differentiating the parabolic curve used to smooth the position data. Mounting sensitive accelerometers in the missile and integrating the accelerations which have been measured is another means of determining velocities.

No matter which method is used the errors involved must be analyzed. The computing machine must be programmed to keep track of these errors, and perhaps go to a more exact method of calculating when they exceed certain bounds. In these cases, accurate manual calculations of the differentials or integrals would be extremely laborious.

MATRIX CALCULATIONS

We now leave the field of data reduction for theoretical, or matrix, calculations. Flutter and vibration problems, among many of C.A.L.'s research projects, use them for their solutions. Although many calculations are involved in data reduction, they are done in small, independent blocks. A single error generally will affect only one result. Many dependent calculations are involved in matrix work, however, and one error in several thousand may invalidate the final result.

Many seemingly unrelated physical problems may be stated mathematically in the same way and be solved by some sort of matrix calculation. A few illustrations would include determination of the calibration coefficients of a wind tunnel balance, calculation of the dynamic stresses on a helicopter rotor or the estimation of the flutter speed of an airplane wing. General matrix calculations may be set up to handle all these varied problems.

"MONTE CARLO" METHOD

High-speed automatic digital computers have made possible the "Monte Carlo" method, a new approach to computing based on the use of random numbers. Named for the gaming tables of Monaco where a spin of the roulette wheel or a throw of the dice generates random numbers, this approach consists of performing a set of mathematical experiments in which some of the variables involved are represented by functions of random numbers. If enough of these mathematical random experiments are performed, statistical conclusions can be drawn from the results, and these conclusions will represent the answer to some physical problem.

Many physical processes are essentially random. The behavior of the discrete molecules which make up the atmosphere, for example, is a random process. The overall effect of the behavior of these molecules is an average of all the individual actions and any physical measurement made of these effects is really a random statistical sample. Viewed in this way, such physical problems lend themselves readily to Monte Carlo techniques for computation of results. This viewpoint has led to a change in the theoretical approach to such problems, and the new approach is more basic and realistic than older analytical methods that assumed physical continuity which did not really exist.

The Monte Carlo method is very useful in aerodynamic studies today. Problems arise in examining the flow of the atmosphere in the thin boundary layer very close to the surface of the airplane, and at extreme altitudes where the distance between molecules is about the same as the size of the body. In these cases, individual collisions of molecules with the body surface become important, and a statistical approach, such as the Monte Carlo method, must be used to give accurate results.

Like any tool, the new method must be used with caution. Quite often, a problem, which because of its discrete nature, seems natural for the Monte Carlo approach, can be solved accurately enough by approximating the discrete variables with continuous variables. These approximations may cut down on the computing involved and may even allow for an analytical solution. Older methods of analysis therefore should not be ignored even for obviously discrete problems.

The automatic, high-speed digital computer is a necessary research tool today. In fact, science has reached a point at which no modern research laboratory can operate effectively without such equipment. But the automatic computer is relatively still a child. Even though great steps forward have been taken, who can predict what advances await us in the future?

REPORTS

"Application of Monte Carlo Techniques to the Analysis of the Ground Controlled Approach System," Blumstein, Alfred, C.A.L. Report No. JA-848-G-2; February, 1954.

"Calculation of Fundamental Natural Vibration Frequencies on the C-60 and C-70 Propeller Blade Designs," Feigenbaum, David and Comeau, Robert E., C.A.L. Report No. AB-713-W-3; December, 1951.

"Calculations of the Fundamental and Higher Order Natural Vibration Frequencies on the F40B, F40C and D40B Propeller Blade Designs," Feigenbaum, David and Comeau, Robert E., C.A.L. Report No. AB-713-W-4; December, 1951.

"I.B.M. C.P.C. Techniques," Houser, Harold D. and Trabka, Eugene A., Report No. XA-771-G-1; April 15, 1953.

Recent C. A. L. PUBLICATIONS

Requests for copies of the following unclassified reports should be addressed to the Editor. Please indicate the company or institution which you represent.

"An expander-compressor method of air cooling," Macdonald, Robert S.; C.A.L. Report HG-591-S-2; December, 1954; 21 pages.

A method of air cooling is proposed whereby the temperature of air is reduced by expanding it adiabatically through an expansion turbine. Air thus cooled can be introduced into the conditioned space as conditioning air or, if the air is maintained in a closed system, it may be used in an intercooler to cool conditioning air.

"Effect of cyclic load frequency on the creep-rupture and fatigue properties of jet engine materials," Yerkovich, Luke A., Guarnieri, Glen J.; C.A.L. Report KB-811-M-17 (WADC TR 55-226); June, 1955; 74 pages.

An investigation is reported on the evaluation of the effects of cyclic loading and load frequency on the elevated temperature creep rupture properties of several jet engine sheet materials.

"Experimental investigation of influence of edge shape on the aerodynamic characteristics of low aspect ratio wings at low speeds," Bartlett, George E., Vidal, Robert J.; paper presented at national meeting, The Institute of the Aeronautical Sciences, June 21-24, 1954; 17 pages.

Some of the more significant results of an experimental investigation of the influence of edge shape on the aerodynamic characteristics of a family of low aspect ratio wings having straight trailing edges and taper ratios between zero and one, are presented.

"Intermittent stressing and heating tests of structural metals," Guarnieri, Glen J.; C.A.L. Report KB-892-M-7 (WADC TR 53-24, Part 3); June, 1955; 69 pages.

Additional data are reported on a continuing program to evaluate the effect of intermittent load and temperature upon the high-temperature creep and rupture properties of aircraft structural alloys.

"Investigation of the compressive, bearing and shear creep-rupture properties of aircraft structural metals and joints at elevated temperatures," Vawter, Frank J., Guarnieri, Glen J., Yerkovich, Luke A., Derrick, George; C.A.L. Report No. KB-831-M-15 (WADC TR 54-270, Part 2); August, 1955; 85 pages.

To supplement existing tensile creep and rupture data, this report records a project to determine the high-temperature creep strengths of a number of structural aircraft alloys when subjected to compression bearing and shear stresses.

"Schlieren and shadowgraph techniques," Schwartz, Daniel S., Russo, Anthony L., Somers, Lowell M., Lenz, Walter C.; reprint from Medical and Biological Illustrations, Vol. VI, No. 1, January, 1956; 33 pages.

Some possible applications to the medical and biological sciences of schlieren and shadowgraph techniques are discussed. Comparison photographs showing the difference between the usual or standard method of photography and the schlieren method are included in the paper.

"The examination of some microscope slides by use of schlieren and shadowgraph techniques," Schwartz, Daniel S., Thornton, Fred, Somers, Lowell M., Lenz, Walter C.; reprinted from Photographic Science and Technique, Series II, Vol. III, No. 1, February, 1956; 3 pages.

This paper presents results of a preliminary study to determine the feasibility and usefulness of examining microscope slide specimens by schlieren and shadowgraph techniques. Photographs taken with and without diffuse light as in a microscope as well as schlieren and shadowgraph photographs are presented for comparison purposes.

About the Authors...

WILLIAM S. HOLMES for the past five years, has been spending his spare time studying the possibility of a true "electronic brain" — a computer that will recognize patterns and orient them, without specific instructions from the mathematician. This problem has been attacked in the past primarily by psychologists. Holmes believes that such a "thinking machine" is possible and may ultimately be developed by computer engineers.

After graduation from Iowa State College with a bachelor of science degree in electrical engineering in 1941, he joined Westinghouse Corporation where he worked on development of ignitron rectifiers and control accessories. Commissioned a Second Lieutenant in the U. S. Army, 1942, he received academic training in all phases of radar theory and served in signal intelligence, receiving the Army Commendation Ribbon. He was discharged in 1946 with the rank of Captain.

He has been with C.A.L. since 1946 when he joined the Physics Department, working initially on missile guidance. In 1947 he was made project engineer on an aircraft instrumentation project to determine Mach number and true air speed by measurement of acoustic propagation effects. In 1950 he was made project engineer on a Navy Defense computer and recently was appointed head of the Electronics branch which is concerned with computer studies and data processing.

He has advanced study credits from George Washington and Cornell Universities. He is a senior member and secretary-treasurer of the Niagara Frontier section of the I.R.E., member of Sigma Xi and the American Association for the Advancement of Science.

DAVID FEIGN has four leisure-time hobbies: photography, flying, do-it-yourself crafts and reading science fiction. "Science fiction is not the source of my computing programs," Feign insists, despite protests from his family that, in view of the time consumed, there must be some relation between the two interests.

As head of the Laboratory's machine computing section, Feign's programs have ranged from the simple reduction of flight data records and preparation of mathematical tables for the wind tunnel department to the incredibly complex simulation of whole air defense systems.

Feign entered the computing field after two years as an aeronautical engineer in C. A. L.'s Wind Tunnel Department. His long-time interest in automatic computing led him to his present position in 1950 when the Laboratory acquired its first Card Programmed Calculator and subsequently set up its first computing section.

Feign received a bachelor of science degree in mechanical engineering from the College of the City of New York in 1944, and a master of science degree in applied mechanics from the University of Buffalo in 1953. He was employed with the Langley Laboratory of the NACA for four and one-half years where he worked principally on airplane dynamic stability research.

He is a member of Pi Tau Sigma, Tau Beta Pi, Sigma Xi, Association for Computing Machinery, the Institute of Aeronautical Sciences, Aircraft Owners and Pilots Association and the National Aeronautic Association.